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DIET OF THE PERIWINKLE *LITTORINA IRRORATA* IN A LOUISIANA SALT MARSH

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ABSTRACT The diet of the periwinkle *Littorina irrorata* was examined. The food substrate utilized most frequently in the field was dead *Spartina alterniflora*. The primary component of the stomach and feces was vascular plant particles. Plant particles, even though a major portion of the diet, were egested unaltered in feces. Other food substrates contributed significantly to the diet. Marsh sediment was utilized by 37% of all snails observed to be feeding, while 4% grazed on live *S. alterniflora*. Algal mats, present on several occasions during the study, were utilized extensively. Comparison of microbial components in dead *S. alterniflora* and marsh sediment with those in the stomach and feces indicated that members of the microbial community of food substrates were assimilated.

INTRODUCTION

Littorina irrorata Say is prevalent in salt marshes from Long Island, New York, to Port Isabel, Texas (Bequaert 1943). Tissue biomass of snails averages 10 g/m^2 in Georgia (Smalley 1958) and 5 g/m^2 in Louisiana (Day et al. 1973). Despite the prevalence of the species, little information is available on its diet. The animal has been classified as a detritus-algae feeder in several studies (Smalley 1958; Teal 1962; Day et al. 1973), but feeding analyses are not reported. The only feeding study is that by Marples (1966), who injected ^{32}P into live *Spartina alterniflora* and marsh sediment with subsequent assay of *L. irrorata* tissue. Radioactivity was not detected in snail tissue when ^{32}P was injected into live plant tissue. However, when ^{32}P was sprayed onto the sediment surface, animal tissue became highly labeled with the isotope. From these results, Marples (1966) concluded that *L. irrorata* is primarily a detritus feeder.

The present study, initiated to determine the diet of *L. irrorata*, included analysis of food substrates utilized in the field and analysis of stomach and feces content.

MATERIALS AND METHODS

Study Area

The study area was a *Spartina alterniflora*-dominated salt marsh in the southwestern section of the Barataria Bay system of coastal Louisiana. This system is described by Day et al. (1973). Population densities of *L. irrorata* in the study area were determined at distances of 4, 6, 8 and 10 m into the marsh. A 0.25 m^2 ring was tossed over the shoulder in one direction. Snails inside the ring on sediment and plant surfaces were enumerated. A total of 96 such determinations, made over a 7-month period, yielded a population density of 24 ± 14 snails per m^2.

Food Substrates Utilized in the Field

Littorina irrorata exhibits periods of both activity and inactivity in the field. For this reason, preliminary studies were conducted to determine the factors controlling periods of feeding. Animal activity and the presence or absence of food in the stomach were related to tide and air temperature as these environmental conditions affect the movement of *L. irrorata* (Smalley 1958; Bingham 1972). These preliminary studies revealed that animals were active and stomachs were full when three conditions prevailed: (1) a water level below the marsh; (2) a daily tide range covering the marsh during a 24-hour tidal cycle; and (3) an air temperature of 14°C or above.

Feeding was examined during seven periods from June to May when the above environmental conditions prevailed. A transect 6 m from and parallel to the marsh edge was established, and all active animals along this transect observed. A snail was recorded as active and feeding if its foot was creeping over the substrate and the head was in contact with the substrate. The substrate utilized by each active snail was tabulated as live (green) *S. alterniflora* (stems or leaves), dead (brown) *S. alterniflora* (attached stems and leaves, or outer sheaths of live plants), or marsh sediment. No distinction was made between utilization of marsh sediment and algal mats during two periods when the latter were available. From 130 to 247 active snails were observed during each feeding period.

Stomach and Feces Analysis

Snails observed to be feeding were randomly collected from the field and immediately placed in a 1-liter beaker containing ice. Snails were held on ice until completion of stomach analysis, within 6 hours. The shell was broken with a hammer and the animal removed. The stomach was opened with a dissecting needle, and the contents withdrawn with a capillary pipette or a dissecting needle. Stomach contents were placed on a microscope slide, covered with a cover slip, and analyzed with a light microscope at 100x, 400x and

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1,000x magnification. The types and relative abundance of material present were recorded.

Fecal pellets were collected from field-gathered snails held at ambient air temperature in a 1-liter beaker. Pellets were dissected in sterile seawater on a glass slide, the mixture covered with a cover slip, and examined with a light microscope at 100x, 400x and 1,000x magnification. The types and relative abundance of material present were recorded.

RESULTS

Dead *Spartina alterniflora* contributed 90% of the diet of *L. irrorata* during one feeding period and was utilized extensively during all periods (Table 1). Marsh sediment was used frequently, except during June. During five of the seven periods, utilization of dead *S. alterniflora* and marsh sediment was more or less equal. Live *S. alterniflora* was grazed during five of the seven periods, but by no more than 11% of the snails observed feeding at any one period.

TABLE 1.

Percentage of food substrates utilized in the field by *L. irrorata*.

Date	No. observed feeding	*S. alterniflora* Live	*S. alterniflora* Dead	Marsh sediment
17 June	153	11	80	9
18 June	171	9	90	1
16 July	206	2	51	47
14 August	247	1	45	54
24 October	164	0	41	59
7 January	130	0	54	46
12 May	203	3	54	43
Total	1,274	$\bar{x}$ = 4	$\bar{x}$ = 59	$\bar{x}$ = 37

Algal mats were an additional food substrate utilized on occasion. This substrate covered large areas of the marsh surface during two periods of the study. During these periods snails grazed the mats frequently.

The stomach contents of 90 snails observed to be feeding contained vascular plant and clay particles as the dominant components. Approximately 75% of the stomachs examined contained vascular plant particles as the primary component, while the remainder contained predominantly clay particles. All stomachs contained considerable numbers of filamentous algae and diatoms. Their presence was particularly noticeable during the two periods when algal mats were present. Additional components of stomachs included nematodes, foraminifera, ostracods, mites, copepods and microorganisms (bacteria, yeasts and molds).

The primary fecal components, vascular plant and clay particles, were mixed and compacted to form the pellet. Other fecal components included diatoms, broken diatom frustules, filamentous algae, foraminifera, mites, bacteria, yeasts, fungal hyphae and spores. Fecal pellets of snails feeding on dead *S. alterniflora* contained an average of 339 plant particles/pellet, ranging from 4 to 4,358. The mean size of plant particles was 0.47 x 0.12 mm, with a range of from 1.10 x 0.02 to 1.63 x 0.25 mm. The abundance of particulate plant particles in feces indicated the efficiency of the snail radula in grazing the plant substrate, and the inability of the snail digestive system to assimilate this ingested material. Plant particles ingested were egested with no significant alteration.

DISCUSSION

The food substrate utilized most frequently in the field by *L. irrorata* was dead *S. alterniflora*. Of 1,274 snails observed to be feeding, 59% utilized this substrate (Table 1). The frequent use of this food substrate explained the dominance of vascular plant particles in the stomach and feces. Vascular plant particles, even though a major portion of the diet, were passed out in the feces without significant alteration.

Although dead *S. alterniflora* was the major portion of the diet of *L. irrorata*, other food substrates contributed significantly to the diet. Marsh sediment was the second most utilized substrate, being the food of 37% of all snails observed to be feeding (Table 1). Live *S. alterniflora* was never utilized extensively by *L. irrorata*, but was grazed by 4% of all snails observed to be feeding (Table 1). Algal mats were a significant portion of the snail diet whenever these were present. The intermittent presence and utilization of this food substrate through the year may be an important contribution to the diet of the snail, since fresh algae have a higher organic matter content and caloric value than plant detritus (Odum 1970).

Studies on the microbial community of dead *S. alterniflora* and marsh sediment were conducted in conjunction with the diet studies. These studies demonstrated the abundance of microbial organisms associated with dead *S. alterniflora* and marsh sediment (Table 2). Comparison of microbial components in dead *S. alterniflora* and marsh

TABLE 2.

The microbial community of dead *S. alterniflora* and marsh sediment.

Members*	Dead *S. alterniflora*	Marsh sediment
I. Autotrophic		
A. Diatoms	2.9×10^6	8.1×10^5
B. Other algae	7.7×10^2	9.8×10^2
II. Heterotrophic		
A. Microorganisms		
1. Bacteria	1.5×10^9	6.7×10^7
2. Fungi	2.6×10^6	3.3×10^5
3. Protozoans	2.4×10^3	5.4×10^2
B. Meiofauna		
1. Nematodes	1.3×10^3	3.1×10^2
2. Others	1.2×10^3	5.1×10^2

*Based on mean numbers per gram wet weight calculated from 3 to 8 replicates. Algae, protozoans, and meiofauna were enumerated using direct microscopic techniques. Bacteria and fungi were enumerated on Marine Agar 2216 (Difco) and M12a (Meyers et al. 1970), respectively.

sediment with those in stomach and feces indicated that some members of the microbial community of these two food substrates were assimilated. Ciliated protozoans, although numerous in food substrates, were absent in stomach and feces samples, indicating their absorption during passage through the gut. Nematodes were abundant in foods, and present in stomachs, but were absent in feces, indicating their digestion. The presence of broken diatom frustules in both stomachs and feces, and the presence of empty and lysing algal sheaths in stomachs, suggested that these microbial components were assimilated. A number of studies have demonstrated that microbial organisms associated with detritus substrates are assimilated by a wide variety of coastal consumers (Newell 1965; Adams and Angelovic 1970; Odum 1970; Fenchel 1970; Chua and Brinkhurst 1973; Wetzel 1977).

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